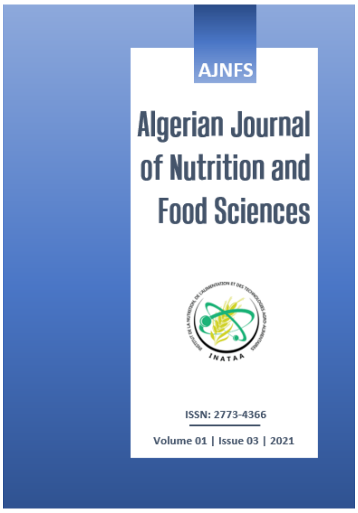

Algerian Journal of
Nutrition and Food Sciences
(AJNFS)

ISSN: 2773-4366

Journal homepage: fac.umc.edu.dz/inataa/revue/

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Published online: November 9, 2021.

To cite this article: Adoui, F., Bouchebtoul, O.A., Abdelaziz, A., Zidoune, M.N. 2021. Preparation of summer squash powder (*Cucurbita pepo*) and winter squash powder (*Cucurbita maxima*) dehydrated and its use in soup preparation. *Algerian Journal of Nutrition and Food Sciences*, 1(3), 11– 16

To link to this article: https://fac.umc.edu.dz/inataa/revue/files/ajnfs0103002.pdf

Algerian Journal of Nutrition and Food Sciences (AJNFS) – Open Access – ISSN: 2773-4366
Volume 01, Issue 03, 2021: 11-16

Original Article

Preparation of summer squash powder (*Cucurbita pepo*) and winter squash powder (*Cucurbita maxima*) dehydrated and its use in soup preparation

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Received September 25, 2021 Accepted October 20, 2021 Available online November 9, 2021

Abstract *The main objective of the present study is to develop dehydrated summer squash (Cucurbita pepo) and winter squash (Cucurbita maxima) powders and to test their use in the preparation of soup. The initial moisture of the summer squash and winter squash used are 94.64 ± 0.45 % and 92.27 ± 0.28 %, respectively, with a pectin content of 7.83 ± 0.57 % for Cucurbita pepo and 6.67 ± 0.76 % for Cucurbita maxima. The winter squash and summer squash powders obtained by hot air drying have a residual moisture of 9% and 8%, for winter squash and summer squash, respectively, they have the same oil retention capacity (1.8 g/g) on the other hand they differ in water retention capacity (4.46 ± 0.23 g/g for winter squash and 2.64 ± 0.53 g/g for summer squash) and solubility (54 ± 12.48 % for winter squash and 40 ± 3.46% for summer squash). Soups prepared from dehydrated squash have lower viscosity values compared to those prepared from fresh squash (163.67 ± 12.42 Pa.s against 253.33 ± 25.16 Pa.s). The tasting panel gave the same sensory appreciation for the soup prepared from winter squash powder and its fresh winter squash control (overall acceptability between 2.2 and 2.8), unlike the summer squash powder soup which received an average appreciation. Regarding the sensory profile, a significant difference is observed for all the attributes between the winter squash powder-based soup and its control. The powdered summer squash-based soup differs significantly from its control for both color and texture criteria, on the other hand no significant difference was observed for the other criteria (external appearance, consistency in the mouth, aroma, salty taste, taste sweet, bitter taste, flavor).*

Keywords *Cucurbita pepo, Cucurbita maxima, dehydration, soups, sensory characterization*

Résumé *La présente étude a comme objectif principal l'élaboration de poudres de citrouille (Cucurbita pepo) et de potiron (Cucurbita maxima) déshydratées et essai de leur emploi dans la préparation de soupe. Les humidités initiales de la citrouille et de potiron utilisés sont de 94,64 ± 0,45 % et de 92,27 ± 0,28 %, respectivement, avec une teneur en pectine de 7,83 ± 0,57 % pour Cucurbita pepo et de 6,67 ± 0,76 % pour Cucurbita maxima. Les poudres de potiron et de citrouille obtenues par séchage à air chaud présentent une humidité résiduelle de 9 % et de 8 %, pour le potiron et la citrouille, respectivement, elles ont la même capacité de rétention d'huile (1,8 g/g) par contre elles différent dans la capacité de rétention d'eau (4,46 ± 0,23g/g pour le potiron et 2,64 ± 0,53g/g pour la citrouille) et la solubilité (54 ± 12,48 % pour le potiron et 40 ± 3,46% pour la citrouille). Les soupes préparées à base de courge déshydratée présentent des valeurs de viscosités plus faibles comparées à celles préparées à base de courge fraiche (163,67 ± 12,42 Pa.s contre 253,33 ± 25,16 Pa.s). Le jury de dégustation a donné la même appréciation sensorielle pour la soupe préparée à base de poudre de potiron et son témoin de potiron frais (acceptabilité globale entre 2,2 et 2,8), contrairement à la soupe de poudre de citrouille qui a reçu une appréciation moyenne. Concernant le profile sensoriel, une différence significative est observée pour tous les attributs entre la soupe à base de poudre de potiron et son témoin. La soupe à base de citrouille en poudre diffère, significativement, de son témoin pour les deux critères couleur et texture par contre aucune différence significative n'a été observée pour les autres critères (aspect extérieur, consistance en bouche, arôme, goût salé, goût sucré, goût amer, saveur).*

Mots clés *Cucurbita pepo, Cucurbita maxima, déshydratation, soupes, caractérisation sensorielle*

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Introduction

Winter squash and summer squash are squash fruits, most often orange in color when ripe, traditionally used as both human and animal food. In culinary terms, it is widely considered a vegetable. They have many culinary uses either as vegetables or as an ingredient in soups, stews, breads, pies and many other dishes. Squash are seasonal crops, when fresh, they are very sensitive to microbial spoilage, even refrigerated and they must be frozen or dried (Doymaz, 2007).

Due to the seasonal nature of vegetable production, these foodstuffs are only available during part of the year, which is short enough which is insufficient to absorb excess production by the market, hence the need for treatments (Colas, 2003). For successful processing and preservation of fresh produce, the most suitable methods for these operations are desiccation, chemical preservation and heat treatment (Burden and Wills, 1992).

Among the physical methods of preserving and preserving foodstuffs is drying. Drying is one of the oldest means of preservation with fermentation (Clergeand and Lionel, 1997). Since the evolution of science and technological revolutions, equipment and devices have been designed and developed to carry out this unitary operation in a controlled manner (Bimbenet, 1984). Drying as an alternative for preservation, allows reducing the weight of the product, decreases the activity of water, therefore, reduces chemical and biochemical reactions, and inhibits the development of microorganisms that spoil the food and those harmful to the consumer (Benssedik *et al.*, 2016).

As already mentioned, summer squash and winter squash have several culinary uses, among which is the preparation of soups. They are prepared by combining different ingredients such as vegetables, poultry, meat or seafood. The selected compounds are boiled in water until the flavors are extracted. Food manufacturers offer a wide range of these products on the market: smooth and particulate soups, clear soups (broths), as well as thickened soups with milk, cream and vegetable purees (from Ancos and Sánchez-Moreno, 2017).

In addition, drying squash is a way of preserving this vegetable in order to ensure its availability throughout the year, on the one hand, and to facilitate distribution and storage. Its preparation as a dehydrated powder can facilitate its introduction into various food matrices.

Thus our work relates to the drying by hot air convection of squash of two varieties (*C. pepo* and *C. maxima*), the characterization of the squash powders obtained and the study of the feasibility of preparing soups based on these powders elaborated by determining the technological and sensory quality of the prepared soups.

(a) **(b)**

Figure 1. (a) Summer squash of the variety *Cucurbita pepo*, (b) Winter squash of the variety *Cucurbita maxima*

Materials and methods

The first product used is the orange-colored summer squash of the *Cucurbita pepo* L. variety, and the second product is the green-colored winter squash of the *Cucurbita maxima* variety (fig. 1) purchased from a farmer in the wilaya of Skikda.

Drying the summer squash and winter squash and preparing the soup

After cleaning and peeling, the summer squash and winter squash are cut into slices with two thicknesses of 8 mm using a cutting system comprising a series of four rigid knife blades in parallel spaced 8 mm apart to cut the products to this dimension and 3 mm using an adjustable kitchen instrument with different thicknesses and then dried in a cabinet dryer at two temperatures 70 °C and 60 °C, at the end of the drying, the squash are crushed with l state of powder.

Preparing the soup

A soup preparation based on summer squash and winter squash powder is made by adding this powder to a boiling mixture prepared with a base ingredient (grated onion, oil and salt), the mixture is cooked over a naked heat until desired consistency and taste is achieved. Control soups made from fresh squash are also prepared with the same ingredients.

Characterization of summer squash and winter squash

Determination of humidity

Humidity is determined according to the AOAC method (1990). A sample of pumpkin or pumpkin weighing 2 g to 3 g is cut and left to dehydrate to a constant mass in an oven at 105 °C. for 24 h.

Determination of the pectin content

The pectin content of summer squash and winter squash samples is determined according to the method of Djeghim (2021). A sufficient quantity of fresh pumpkin or pumpkin is dried at 50 °C for 2 hours in an air dryer brand MAXEI, type MC-100. The dried product is ground into a fine powder using a mortar.

The ground pulp (10 g) is added to a solution of 200 ml of 0.1 N hydrochloric acid (HCl), then brought to a boil at 90 °C for 45 min then immersed in ice in order to stop the hydrolysis process. The supernatant is recovered after filtration and the pectin is then precipitated with two volumes of 96 % alcohol for one volume of supernatant (2 v/v) overnight in the absence of light.

The pellet is collected after centrifugation (Sigma 3-30 K, Osterodeam Harz, Germany) at 4 °C for 15 min with a force of 5000*g, then dried at 65 °C to constant weight. The pectin yield is expressed in g/100g of dried sample.

Characterization of summer squash and winter squash powder

Water retention capacity

Determined using methods modified from the work of Koksel *et al.* (2008). A quantity of 2 grams of powder sample of the dried product is dispersed in 20 mL of distilled water in a 30 mL centrifuge flask. The vials are shaken, and left to stand for 5 to 30 min at room temperature to study the effect of the standing time on the water retention capacity, then centrifuged at 3500*g speed for 30 min with a centrifuge. (sigma 3-30 K, Osterodeam Harz, Germany). The supernatant is then removed. The water retention capacity (WRC) (g water / g powder) is calculated as follows:

$$WRC\left(\frac{g}{g}\right) = \frac{[(m_{after} - m_{before}) - m_{poudre}]}{m_{poudre}}$$

m_{after} Mass of the vial containing the product after centrifugation (g).
m_{before} Mass of the vial alone (g).

Oil retention capacity

It is determined according to the method of Tiezheng *et al.* (2017). One gram (m_0) of vegetables was weighed before being placed in a centrifuge tube. Then, 10 ml of soybean oil was added and mixed in a vortex for 5 min. The sample is allowed to stand at room temperature for 30 min and then centrifuged at 3000g for 20 min. The supernatant is decanted and the centrifuge tube with the precipitate is weighed (m_2). The oil retention capacity (ORC) is calculated as follows:

$$ORC\left(\frac{g}{g}\right) = \frac{m_2 - m_1}{m_0}$$

m_1: empty centrifuge tube

Solubility

The solubility of summer squash and winter squash powder is determined using the procedure developed by Cano-Chauca *et al.* (2005). One gram of powder (dry base) is dispersed in 100 ml of distilled water while mixing at high speed (13,000 rev / min) for 5 min using an Osterizer mixer (Oster, Mexico). The dispersed pumpkin or pumpkin powder is then centrifuged at 3000*g for 5 min. A 25 mL aliquot of the supernatant is carefully pipetted and transferred to a pre-weighed aluminum dish and then oven dried at 105 °C. for 5 h starting from 2 h of drying, weightings are carried out every hour. The solubility of the powder (S in %) is determined by taking the difference in weight.

$$S(\%) = \left(\frac{mass\ of\ dried\ supernatant}{mass\ of\ test\ sample}\right) \times 100$$

Characterization of the soup made from summer squash and winter squash powder

pH

The pH of the summer squash and winter squash soup samples was measured using a pH meter (Hanna pH 211, USA) by direct immersion of the electrode in the soup at 20 °C (AFNOR, 1982).

Brix degree determination

Measurement, at a temperature of 20 °C, of the refractive index of the prepared sample, and conversion of this index into a soluble dry residue using a refractometer (AFNOR, 1982).

Determination of viscosity and shear rate

Viscosity is defined as the resistance of a fluid to uniform flow without turbulence, it is primarily a function of its water content, composition and temperature. It is measured using a viscometer which determines the viscosity of a fluid by the rotation of the four rotors at speeds of 1000 rpm and is expressed in Pa.s (Linden, 1981).

Sensory analyzes

Samples of soup prepared from dried summer squash and winter squash were subjected to a sensory evaluation in order to determine their sensory profiles and to know the degree of acceptability of these preparations by the tasters. Soups made from fresh summer squash and winter squash are taken as a witness.

Hedonic test

This test is designed to measure the degree of appreciation of a product. We use the most liked to least liked category scale. The tasters choose, for each sample, the category that corresponds to their level of appreciation (Watts *et al.*, 1991).
For our test, we targeted 5 criteria used to assess the quality and sensory properties of the two soup preparations (color, appearance, consistency, taste, smell, vegetable taste and aroma). The interval scale used for the hedonic approach of the different criteria is based on the following expressions: color (1. Pale yellow, 2. Yellow, 3. Greenish yellow, 4. Orange yellow, 5. Orange), aspect (1. Smooth, 2. Medium, 3. Granular), consistency (1. Liquid, 2. Viscous), the criteria: aroma, salty taste, sweet taste, bitter taste and vegetable flavors (1. Very strong, 2. Strong, 3. Moderate, 4. Weak, 5. Absence), texture in the mouth (1. Very smooth, 2. Smooth, 3. Moderately smooth, 4. Grainy, 5. Absence) and finally the overall appreciation (1. Very good, 2. Good, 3. Fair, 4. Poor, 5. Bad) (Watts *et al.*, 1991).

Preference test

As its name suggests, the objective of the preference test is to determine a classification of preference between the products tasted. The classification test consists in presenting all the products directly to the subject who must give a classification of these products according to his assessment (NF V 09-012) described by AFNOR **(**1984).

7. Statistical analysis

The results obtained are expressed as the mean ± standard deviation. Data entry was performed using Microsoft Excel 2013 software. Sensory analysis results are subjected to a Student T test to compare values at a 5% significance level using MINITAB.

Results and discussion

Drying kinetics

Figure 2 shows the evolution of the water content for the pumpkin and the pumpkin has three distinct phases, a first phase represents the drying during the first three hours when the humidity decreases slightly from 94.62% to 13% for the pumpkin and 92.27% to 22% for pumpkin on a wet basis. The second phase is the next two hours when the humidity drops very quickly to 8% for pumpkin and 9% for pumpkin on a wet basis. The third phase shows a weak change in humidity, which indicates that during this phase we are witnessing the elimination of part of the bound water.

According to the study by Benssedik *et al.* (2016), drying pumpkin slices with an initial humidity of 87 % and 1.03 cm thick at 70 °C for 5 hours reaches a final moisture content of 3% on dry base.

From figure 3 which shows the rehydration rate over time of the two varieties of dried squash. The rate of rehydration increases with increasing time. After one hour, the pumpkin's rehydration rate reaches 80%, but the same rate is obtained for the pumpkin after an hour and a half. In addition, during the other hours of rehydration we noticed that the rate of rehydration increased gradually for both varieties.

Our result is similar to the study by Seremet *et al.* (2016), and which can be explained by the porosity and the water retention capacity of the dried material.

Features of dehydrated squash powder

Table 1 shows the results of the wet pumpkin and pumpkin moisture test, where it indicates that the average humidities are 94.62 ± 0.45% and 92.27 ± 0, 28%, respectively. These values are comparable to those found in the literature (Raquel *et al.*, 2011; Rakcejeva *et al.*, 2011; Belkebla and Makhloufi, 2016).

Our results show that the pectin content of summer squash is higher than that of winter squash (7.83 ± 0.57% vs. 6.67 ± 0.76%). The pectin content appears to differ between varieties of squash. The pectin content, according to the literature, varies from 5 to 10% for the variety *Cucurbita maxima* (Yoo *et al.*, 2012; Preethi *et al.*, 2017).

Table 2 shows the results of the physicochemical characteristics of powders of varieties of squash. The water retention capacity (WRC) and solubility of dehydrated pumpkin is greater than that of pumpkin, and these values may be due to the presence of certain soluble components such as sugar and soluble fiber (Andrade-Mahecha *et al.*, 2012). Powders with high WRC values may have more hydrophilic constituents, such as polysaccharides (Kaushal *et al.*, 2012). In addition, soluble fiber has a high hydration capacity and forms viscous solutions, thus improving stability and decreasing water separation from the product (Kaushal *et al.*, 2012; Saura Calixto and Goni, 2006).

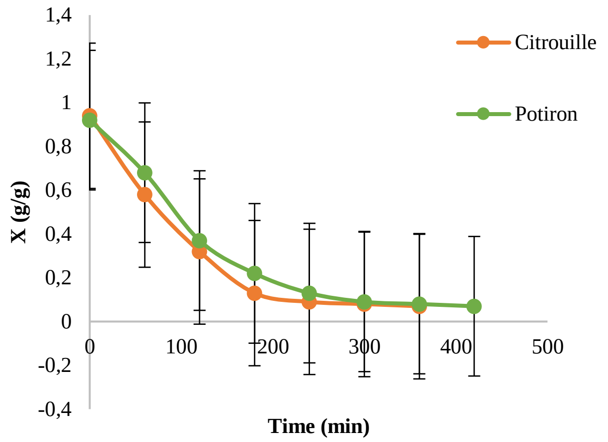

Figure 2. Evolution of the water content during drying for the two varieties, at 70 ° C for the summer squash and at 60 ° C for the winter squash

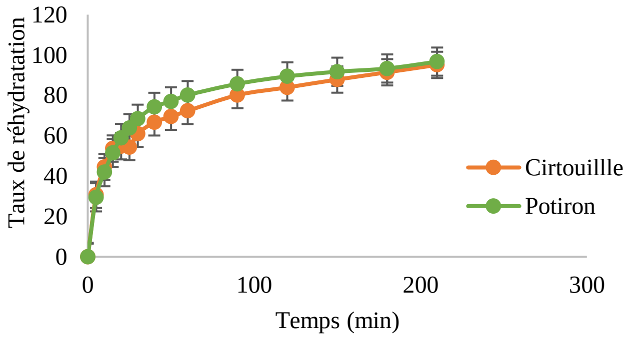

Figure 3. Time-dependent hydration rate of the two varieties of dried squash

Table 1. Moisture and pectin content of the two varieties of squash studied

	Summer squash (*Cucurbita pepo*)	**Winter squash** (*Cucurbita maxima*)
Moisture (%)	94,62 ± 0,45	92,27 ± 0,28
Pectin content (%)	7,83±0,57	6,67±0,76

Table 2. Physicochemical characteristics of powders of varieties of squash.

	Powder of summer squash	**Powder of winter squash**
Water retention capacity (g/g)	2,64± 0,53	4,46± 0,23
Oil retention capacity (g/g)	1,8 ± 0,03	1,8± 0,21
Solubility (%)	40±3,46	54±12,48

Table 3. Sensory profile of soups prepared from dried squash with 30 tasters.

	Color	Exterior appearance	consistency in the mouth	Aroma	Texture	Salty taste	Sweet taste	Bitter taste	Flavor
Summer squash powder soup	2,93±0,94	2,77±0,50	1,5±0,50	2,47± 1,01	4,17±0,69	2,3± 0,87	4,47± 0,77	3,93± 1,17	2,27± 1,11
Control soup (fresh summer squash)	4,97±0,18	1,3±0,46	1,87±0,34	3,1±1,09	1,7±0,87	3,77± 0,85	3,03± 0,96	4,7± 0,59	2,87± 1,16
Winter squash powder soup	2,67±0,92	2,1±0,66	1,4±0,85	2,7±1,17	3,37±0,99	2,57±1,07	4,27± 0,73	3,97± 0,99	1,97± 0,92
Control soup (winter squash)	1,63±0,66	1,27±0,44	1,83±0,37	3,43± 0,89	1,57±0,77	3,83±0,94	2,63± 1,24	4,67± 0,80	2,97± 1,15

Regarding the oil retention capacity (ORC), it is comparable for the two varieties (1.8 ± 0.21 g/g). These results can be explained by the high number of hydrophobic groups in the molecules of these samples (Tharise *et al.*, 2014). Samples with high ORC values can act as emulsifiers and also play an important functional role in improving the viscosity and texture of formulated foods (Emine and Duygu, 2015).

Physicochemical and sensory characteristics of summer squash and winter squash soup

The pH values of the two prepared soups as well as their control are close to the neutral zone (between 5.71 and 5.91).

Concerning the viscosity, the values obtained for the powder-based soups are lower compared to the control soups for the two varieties. Analysis of the results with the Student test indicates that there is a significant difference ($p < 0.05$) for the two powder-based soups compared to their controls. This difference can be explained by the effect of drying which can affect and modify the structure of the fibers, especially the pectin which is involved in the viscosity of the soup.

Certain sensory attributes of soups prepared from dried squash were investigated by a sensory test. The results obtained are presented in table 3.

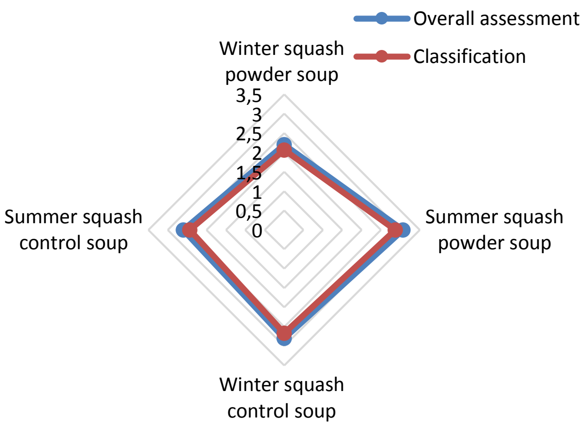

Figure 4. Overall assessment and classification of the four prepared soups

Among the four prepared soups, the three soups ranked first (winter squash powder based soup, summer squash control soup and winter squash control soup, respectively) received scores between 2.2 and 2.8 which allows us to consider them good. The summer squash powder soup received a score of 3.07 from an average review and is ranked last.

The aroma and taste criteria were judged to be pleasant for the two powder-based soups, on the other hand, were unpleasant for the other soups (controls).

Our results show that pumpkin powder soup had a higher preference compared to pumpkin powder soup. Dehydrated pumpkin soup has the best technological and sensory characteristics.

The results of the overall assessment and ranking test are shown in figure 4. It appears that drying alters the sensory qualities of the two varieties of squash studied, positively for some attributes and negatively for others.

Conclusion

The main objective of the present study is to develop dehydrated summer squash (*Cucurbita pepo*) and winter squash (*Cucurbita maxima*) powders and to test their use in the preparation of soup.

The drying of two varieties of squash (*Cucurbita pepo* and *Cucurbita maxima*) in a hot air at 70 °C for the pumpkin and 60 °C for the pumpkin allowed the reduction of their humidity to values of 8% (summer squash) and 9 % (winter squash) without altering its organoleptic properties. Dehydrated squash lend themselves well to rehydration and reach 80% after 1 hour 30 minutes. The soup made from winter squash powder is more popular than that made from summer squash. The winter squash is the most cultivated variety of squash and the most available on the Algerian market. Preparation of soups by introducing other ingredients that may enhance the enjoyment of these soups should be considered.

Given the pectin content of the varieties of squash studied as well as the technological properties of the dehydrated powders prepared, in particular, the solubility and the water and oil retention capacity, these powders can be introduced into different food matrices and provide different techno-functional properties of the products produced.

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